

AMENDMENTS TO THE CLAIMS

1. (Currently Amended) A concentric spectrograph comprising:

a diffraction grating having an optical axis, a meridian plane, a grating concave surface and a set of ~~parallel~~ grating grooves on said concave surface, said grating grooves generally extending in a groove direction, and said meridian plane containing the grating optical axis and extending transversely ~~perpendicularly~~ to the ~~parallel~~ grating grooves;

a field lens having a lens convex surface, a relatively planar lens surface, said relatively planar lens surface being relatively planar relative to the shape of ~~said~~ a lens convex surface, and a lens an optical axis, wherein said lens convex surface faces and is substantially concentric with said grating concave surface, said optical axes of said grating and said lens ~~are~~ being substantially coincident and said relatively planar lens surface ~~extends perpendicularly~~ extending transversely to said lens optical axis;

an entrance port positioned to introduce incident polychromatic light to the ~~lens~~ relatively planar lens surface at a location on said ~~lens~~ relatively planar lens surface ~~out of said meridian plane and~~ on one side of said meridian plane;
and

an exit port located to receive a non-zero order of diffracted light emerging from said lens planar surface at a location ~~out of said meridian plane~~ on the other side of the meridian plane from the incident polychromatic light, without significant mixing with adjacent orders of diffracted light

2-6. (Cancelled)

7.(Previously Presented) The spectrograph of claim 1 wherein said entrance port and said exit port are located at the same perpendicular distance from said meridian plane.

8. (Previously Presented) The spectrograph of claim 1 further comprising a housing enclosing the grating and lens for reducing stray light contamination.

9. (Cancelled)

10. (Original) The spectrograph of claim 1 further comprising at least one optical filter positioned between one of said ports and said planar surface of said lens.

11. (Previously Presented) The spectrograph of claim 1 further comprising a reflective surface between said entrance port or said exit port and said lens.

12. (Previously Presented) The spectrograph of claim 11 wherein said reflective surface is planar and has an axis normal to said reflective surface, said axis

forming an angle with said grating optical axis, said angle optionally being about 45 degrees.

13.-65. (Cancelled)

66. (Previously Presented) A method for dispersing light comprising:
passing polychromatic light through an entrance port located on a first side of and at a perpendicular distance from a meridian plane of a concave diffraction grating, said meridian plane containing the grating optical axis and extending perpendicularly to the parallel grooves;

directing said polychromatic light with a lens toward said grating so that said light is incident on said grating;

diffracting said light with said diffraction grating, thereby dispersing said light; and imaging said dispersed light with said lens at an exit port located on a second side of said meridian plane for receiving a non-zero order of diffracted light without significant mixing with adjacent orders of diffracted light.

67-83. (Cancelled)

84. (Previously Presented) A concentric spectrograph according to claim 1 wherein the exit port is located to receive first order diffracted light, optionally negative first order diffracted light, without significant mixing with second order

diffracted light and wherein the first order diffracted light is received without significant mixing with zero order reflected light.

85. (Previously Presented) A concentric spectrograph according to claim 1 wherein the entire cross-sectional area of each entrance or exit port is located to receive said non-zero order of diffracted light without receiving light from other diffracted orders.

86. (Previously Presented) A concentric spectrograph according to claim 1 wherein the entire cross-sectional area of each entrance or exit port is located at a distance from the meridian plane.

87. (Previously Presented) A concentric spectrograph according to claim 1 wherein the grating is a reflective holographic grating.

88. (Previously Presented) A concentric spectrograph according to claim 1 wherein the exit port has an elongated shape, optionally a rectangular shape, having a longitudinal axis that is parallel to the meridian plane.

89. (Previously Presented) A concentric spectrograph according to claim 88 wherein the entrance port has a symmetrical shape, optionally an elongated rectangle, and a small size.

90. (Previously Presented) A concentric spectrograph according to claim 1 wherein the convex lens surface and the concave grating surface are spherical surfaces.

91. (Previously Presented) A concentric spectrograph according to claim 1 wherein the spectrograph has a focal plane and at least one of the entrance and exit ports faces the lens planar surface and- is near the focal plane.

92. (Previously Presented) A concentric spectrograph according to claim 1 comprising a housing formed from an optically opaque material to prevent stray light from entering the housing and wherein the concave grating, the field lens and the entrance and exit ports are mounted in the housing.

93. (Previously Presented) A concentric spectrograph according to claim 1 adapted for incident polychromatic light comprising light of wavelength of from about 350 nm to about 800 nm.

94. (Previously Presented) A concentric spectrograph according to claim 1 comprising multiple pairs of entrance and exit ports.

95. (Previously Presented) A concentric spectrograph according to claim 1 wherein the spectrograph comprises at least two said entrance ports and at least two said exit ports, the entrance being paired to the exit ports so that light

incident at one of the entrance ports of a pair is received by the exit port of the respective pair.

96. (Previously Presented) A concentric spectrograph according to claim 95 wherein the entrance ports are each located on the one side of the meridian plane and the exit ports are each located on the other side of the meridian plane.

97. (Previously Presented) A concentric spectrograph according to claim 95 comprising two entrance ports located on respective opposed sides of the meridian plane, the two exit ports also being located on respective opposed sides of the meridian plane.

98. (Currently Amended) A concentric spectrograph according to claim 1 wherein the grating concave surface and the field lens convex surface are spherical wherein the ratio of the radius of curvature of the convex lens to the radius of curvature of the grating concave surface is roughly about 0.4:1 and wherein the spacing between the convex lens surface and the grating concave surface is roughly about 0.6 times the grating radius of curvature.

99. (Previously Presented) A concentric spectrograph according to claim 1 wherein the grating concave surface is spherical with a radius of curvature of about 250 mm and a diameter of about 130 mm, the field lens convex surface is also spherical and has a radius of curvature of about 94 mm and a diameter of

about 110 mm, the distance between the grating concave surface and the lens convex surface is about 155 mm and the spectrograph has an F-number of about 1.3.

100. (Previously Presented) A concentric spectrograph according to claim 1 wherein the spectrograph entrance and exit ports are positioned near a focal plane of the spectrograph and the optical path lengths at the ports are similar.

101. (Previously Presented) A concentric spectrograph according to claim 100 comprising a reflective surface in the optical path adjacent the entrance port or the exit port, or both, to move the focal plane at the respective port.

102. (Previously Presented) A concentric spectrograph according to claim 101 comprising a prism providing said reflective surface wherein a portion of the field lens in the respective optical path has a reduced thickness to preserve the optical path length at the respective port.

103. (Previously Presented) A concentric spectrograph according to claim 1 wherein input light is incident upon the grating at a non-perpendicular angle, incident light fills the grating area and diffracted incident light is receivable at the exit port from all the filled grating area.

104. (Previously Presented) A concentric spectrograph according to claim 1 wherein the entrance and exit ports are laterally displaced on opposite sides of a

plane through the optical axis and parallel with the grating lines, being a plane perpendicular to the meridian plane.

105. (Previously Presented) A method according to claim 66 wherein the entrance and exit ports are each located at a distance from the meridian plane in opposite directions from the meridian plane, the distances being the same and wherein the exit port is located to receive the order of light without mixing with adjacent orders of diffracted light, the received order being the negative first order.

106. (Previously Presented) A method for diffracting two beams of light employing a concentric spectrographic apparatus, the apparatus including a grating, a lens, a primary entrance port, a primary exit port, a secondary entrance port and a secondary exit port, the method comprising the elements of:

- a) providing a first polychromatic light beam to the primary entrance port;
- b) refracting the first light beam with the lens to diverge the beam toward the grating;
- c) reflectively diffracting the first light beam at the grating to form a first diffracted beam;
- d) imaging the first diffracted light beam with the lens at the primary exit port;
- e) providing a second polychromatic light beam to the secondary entrance port;

- f) refracting the second light beam with the lens to diverge the beam toward the grating;
- g) reflectively diffracting the second light beam at the grating to form a second diffracted beam; and
- h) imaging the second diffracted light beam with the lens at the secondary exit.

107. (Previously Presented) A method according to claim 106 wherein elements e) - f) are performed during the performance of elements a) - d).

108. (Previously Presented) A method according to claim 106. wherein performance of elements e) - f) is alternated with performance of elements a) - d).

109. (Previously Presented) A method according to claim 106 wherein the first and second polychromatic light beams are each provided to the lens at respective lens locations displaced from the meridian plane.

110. (Previously Presented) A method according to claim 106 wherein the first and second diffracted light beams are each received from the lens at respective locations displaced from the meridian plane.

111. (Currently Amended) A ~~modified concentric~~ spectrograph comprising:

a grating having an optical axis, a meridian plane, and a concave surface, said meridian plane having a first side and a second side;

a lens having a substantially planar surface, a convex surface, and an optical axis, wherein said convex surface is facing said concave surface, said optical axes being substantially coaxial or parallel to each other;

a primary entrance port being located substantially out of said meridian plane toward said first side; and

a primary exit port being located substantially out of said meridian plane toward $\frac{1}{2}$ said second side for receiving an order of light that maximizes throughput and minimizes astigmatism.

112. (Currently Amended) A ~~modified concentric~~ spectrograph comprising:

a grating having an optical axis, a meridian plane, and a concave surface;

a lens having a substantially planar surface, a convex surface, and an optical axis, wherein said convex surface is facing said concave surface, said lens optical axis is substantially coaxial with said grating optical axis, and a primary focal plane is formed perpendicular to said optical axis facing said planar surface of said lens;

a primary entrance port near said primary focal plane at an intersection between a first axis and a second axis, wherein said first axis is parallel to, and

offset in a first direction from, said meridian plane and said second axis is perpendicular to said meridian plane and offset from said optical axis; and

a primary exit port near said primary focal plane located at a second perpendicular distance from said meridian plane, in a second direction opposite said first direction for receiving an order of light that maximizes throughput and minimizes astigmatism.

113. (Previously Presented) The spectrograph of claim 112 wherein the primary exit port is located for receiving a negative first order of diffracted light.

114. (Previously Presented) The spectrograph of claim 112 wherein said exit port is elongated along said first axis.

115. (Previously Presented) The spectrograph of claim 112 wherein said entrance port is for receiving light from a primary light source, said spectrograph further comprising a housing for preventing light coming from a secondary light source external to said housing from contaminating said light-from said primary source in said housing.

116. (Previously Presented) The spectrograph of claim 112 further comprising:
a secondary entrance port; and

a reflective surface between said primary entrance port and said lens, wherein said reflective surface forms a modified focal plane in which said secondary entrance port is located.

117. (Previously Presented) A modified concentric spectrograph comprising:

a grating having an optical axis, a meridian plane, and a concave surface;
a lens having a substantially planar surface, a convex surface, and an optical axis, wherein said convex surface is facing said concave surface, said optical axes are substantially collinear and said surfaces are substantially concentric, and a primary focal plane is formed perpendicular to said optical axis facing said planar surface of said lens;

a primary entrance port near said primary focal plane at an intersection between a first primary axis and a second primary axis, wherein said first primary axis is parallel to and offset from said meridian plane and said second primary axis is perpendicular to said meridian plane and offset from said grating optical axis;

a primary exit port near said primary focal plane located at a first perpendicular distance from said meridian plane, said first perpendicular distance being in a second direction opposite said first direction for receiving an order of light that maximizes throughput and minimizes astigmatism;

a secondary entrance port near said primary focal plane at an intersection between a first secondary axis and a second secondary axis, wherein said first secondary axis is parallel to and offset from said meridian plane and said second secondary axis is perpendicular to said meridian plane and offset from said grating optical axis; and

a secondary exit port near said primary focal plane located at a second perpendicular distance from said meridian plane in said second direction.

118. (Previously Presented) The spectrograph of claim 117 wherein said non-zero order is a negative first order.

119. (Previously Presented) The spectrograph of claim 117 wherein said primary entrance port is for receiving light from a primary light source, said spectrograph further comprising a housing around in which said grating and said lens is placed.

120. (Previously Presented) The spectrograph of claim 117 wherein at least one of said ports is in said primary focal plane.

121. (New) A concentric spectrograph as in claim 1, wherein said exit port is positioned to receive a first-order image.

122. (New) A concentric spectrograph as in claim 1, wherein said exit port is positioned to receive a negative first-order image.

123. (New) A concentric spectrograph as in claim 1, wherein said entrance and exit ports are positioned proximate the focal plane of the spectrograph.

124. (New) A concentric spectrograph as in claim 1, wherein said entrance and exit ports are positioned relative to said lens convex surface and said grating concave surface to reflect light which is reflected by said lens convex surface towards said grating concave surface for reflection generally towards said lens convex surface to follow a path which avoids said exit port.

125. (New) A concentric spectrograph comprising:

a diffraction grating having an optical axis, a meridian plane, a grating concave surface and a set of grating grooves on said concave surface, said grating grooves generally extending in a groove direction, and said meridian plane containing the grating optical axis and extending transversely to the grating grooves;

a field lens having a lens convex surface, a relatively planar lens surface, said relatively planar lens surface being relatively planar relative to the shape of said, lens convex surface, and a lens optical axis, wherein said lens convex surface faces and is substantially concentric with said grating concave surface, said optical axes of said grating and said lens being substantially coincident and said relatively planar lens surface extending transversely to said lens optical axis;

an entrance port positioned to introduce incident polychromatic light to the relatively planar lens surface at a location on said relatively planar lens surface on one side of said meridian plane; and

an exit port located to receive diffracted light emerging from said lens planar surface at a location on the other side of the meridian plane from the incident polychromatic light, said entrance and exit ports being positioned relative to said lens convex surface and said grating concave surface to reflect light which is reflected by said lens convex surface towards said grating concave surface for reflection generally towards said lens convex surface to follow a path which avoids said exit port.

126. (New) A spectrograph as in claim 111, wherein said optical axes are parallel to and offset from each other.

127. (New) A spectrograph as in claim 111, wherein said lens is spherical.

128. (New) A concentric spectrograph comprising:

a diffraction grating having an optical axis, a meridian plane, a grating concave surface and a set of grating grooves on said concave surface, said grating grooves generally extending in a groove direction, and said meridian plane containing the grating optical axis and extending transversely to the grating grooves;

a field lens having a lens convex surface, a relatively planar lens surface, said relatively planar lens surface being relatively planar relative to the shape of said lens convex surface, and a lens optical axis, wherein said optical axes of said grating and said lens substantially coincide and said relatively planar lens surface extends transversely to said lens optical axis;

an entrance port positioned to introduce incident polychromatic light to the relatively planar lens surface at a location on said-relatively planar lens surface on one side of said meridian plane; and

an exit port located to receive a non-zero order of diffracted light emerging from said lens planar surface at a location on the other side of the meridian plane from the incident polychromatic light, and, overall, to tend to maximize throughput and tend to minimize astigmatism.

129. (New) A concentric spectrograph comprising:

a diffraction grating having an optical axis, a meridian plane, a grating concave surface and a set of grating grooves on said concave surface, said meridian plane containing the grating optical axis and extending transversely to the grating grooves;

a lens having a lens convex surface, a relatively planar lens surface, said relatively planar lens surface being relatively planar relative to the shape of said lens convex surface, and a lens optical axis;

an entrance port positioned to introduce incident polychromatic light to the relatively planar lens surface at a location on said-relatively planar lens surface on one side of said meridian plane; and

an exit port located to receive first order of diffracted light emerging from said lens planar surface at a location on the other side of the meridian plane from the incident polychromatic light.

A concentric spectrograph as in claim previous, wherein said exit and entrance ports are on opposite sides of a second plane which is both i) perpendicular to said meridian plane and ii) passes through said optical axis of said grating.